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1. Lunar Studies

A. Atlases. As outlined in the Eighth Semi-Annual Status Report, the Consolidated Lunar Atlas preparations have been largely confined to the accumulation of new basic lunar photography, mostly with the 61-inch NASA telescope at the Catalina observatory, but also from other sources as they become available. The latter include the 61-inch Naval Observatory full-moon photographs obtained at Flagstaff (U. S. Navy-ACIC), the other Flagstaff telescopes (20", 24", 74"), additional photography with the Lick 120-inch telescope, and results from the Pic du Midi made available through ACIC, St. Louis. Before the final Atlas selection is made, our staff will spend time at ACIC, St. Louis, to assess the now very voluminous file (over 20,000) of Pic du Midi records (only a small fraction of which is of research quality, however). The new 61-inch photography is made on 5 x 7 inch films (so far mostly Tri-X) at the 225 ft focus (3 arc seconds per mm), which fits very well each of the 44 fields of the Photographic Lunar Atlas and its up-dated revision, the Consolidated Lunar Atlas. Thus, superior new plates may be substituted for complete Atlas fields. The Consolidated Atlas will be photographic (format of the Ranger Atlases), at scale 1:2 million.

The printing of the photographic editions of the Ranger VIII and IX Atlases was done in Tucson under JPL contract at a commercial company, supervised by Mr. Whitaker. Each atlas volume contains 170 sheets; the edition was 150 copies, therefore, requiring altogether over 51,000 photographs of 11 x 14 inches, between the two atlases. As with the three Ranger VII Atlases, we are satisfied that everything reasonable has been done to ensure that the Atlases retain the full photographic detail of the originals. The distribution of these Atlases is to be made early 1966 by JPL.

Very important progress was recently made in systematic photography of the lunar limb at maximum librations. The result is that already at present substantial improvements can be made in mapping and rectifying photographs of the limb areas. We are preparing for the production of a new Rectified Lunar Atlas to follow the production of the Consolidated Atlas. The plan is to produce also this revision in the form of photographic charts, since it is virtually impossible to retain the halftone information of photographs except by actual photography. The new Rectified Atlas will include also rectified copies of the remarkable Zond-3 records.

B. Crater Diameters, Coordinates, Maps, and Lunar Nomenclature. The last part of the crater diameter and nomenclature studies is being prepared for publication as LPL Communication No. 70. This publication lists the details for 7932 craters, so that the entire work, in the form of four quadrant catalogs (Comm. LPL Nos. 30, 40, 50, 70), lists positions, diameters, and nomenclature for about 17,000 lunar craters on the visible hemisphere (essentially all craters larger than 3.5 km diameter).

The 44 associated maps are rather crowded in some of the limb regions and this defect will be overcome by the additional publication of a special lunar limb map in eight sheets. One sheet is ready for publication and the second is about half complete.

C. Physical and Tectonic Studies of the Lunar Surface; Ranger VIII and IX Reports.

The major effort of the LPL staff engaged in lunar studies was made in connection with the preparation of the Ranger reports. The Ranger VIII and IX records presented such a wealth of new information that a research program of at least two years was indicated. In the program for the main Ranger report the topics to be dealt with had to be limited. The main report was essentially completed by the end of 1965; it will be 214 (large) pages in print. It was composed jointly by Messrs. Strom, Le Poole, and the writer. Mr. Whitaker produced a separate report of 20 pages. A considerable amount of field work on terrestrial lava flows was undertaken in direct support of the Ranger evaluation studies. It involved trips, both by air and on the ground, of the large flows near Grants and Carrizozo, New Mexico, and to several lesser flows. Mr. Strom attended the Lunar Geological Field Conference and associated field trips in August 1965 organized by the New York Academy of Sciences and the State of Oregon, and quartered at Bend, Oregon. Later, Dr. Kuiper received a personal visit from the State Geologist, Mr. Dole, the invitation to visit the State with the promise of a geologist guide and an airplane at our disposal. This invitation was accepted (for August 1966).

The Ranger report covers approximately half the program envisaged, with the remaining studies to be done in 1966. The progress in our understanding of the lunar surface, based on the Ranger records and associated research, has been unique in the long history of lunar studies. It should not be assumed, however, that this program is complete. The results will figure heavily in Volume V of The Solar System.

Among the new and exciting problems stimulated by the Ranger program are those of collapse structures, in lava fields and above subsurface mines. A beginning with these studies has been made, with the results described in the Ranger report. Another subject is the significance of the lineaments, their origin and bearing on the history of the lunar rotation. Reference is made to the Ranger report for progress on this subject also.

2. Planetary and Laboratory Studies

Over 1000 high-resolution photographs have been obtained of Jupiter and Saturn with the 61-inch NASA telescope, many on High Speed Ektachrome. Experiments with infrared color film have begun. Laboratory and field studies have been made comparing the infrared spectral distribution of Mars and certain areas of the moon with terrestrial rocks and lava fields. A beginning has been made with the publication of these results (see list of publications, Sec. 6).

3. Wide Band Photometry, 0.3-20 Microns

Dr. Johnson and his associates have nearly finished the preparation for a large catalog of photometry of some 1567 bright stars in 8 colors, giving V, U-V, B-V, V-R, V-I, V-J, V-K, V-L and the spectral and luminosity classes. Three-color data for many additional fainter stars are also included. A partial listing of results has been published as a Supplement to Sky and Telescope, as referred to in the previous report. The catalog of the original results will be published as No. 71 of the LPL Communications, which will have about 140 large pages.

Dr. Low has essentially completed the IR scanner to be used principally at 20 microns. Preliminary tests with the 28-inch telescope have been satisfactory and the observations are scheduled to begin early 1966. The utilization of this equipment on the 61-inch NASA telescope will require the construction of a high-precision tangent arm to remove some remaining lost motion in declination, disturbing during the scans (precision required is better than 0.5 arc seconds). This tangent arm is currently being designed. Its cost will be somewhat below \$10,000. Observations of the sun have been made at 20 microns and 1 mm with the 5-foot IR telescope constructed by Dr. Johnson. The 20 μ lunar scans will be of great importance for classifying the lunar surface into thermal (and composition) provinces.

A very interesting program has begun under Dr. Low's direction of observing sun, moon, and planets at 1 mm and 300 microns from a specially equipped jet flying at 45,000 ft. This program is conducted at the Naval Ordnance Test Station at China Lake, California, jointly with Dr. Pierre St. Amand. Mr. Gillespie has passed the tests for high-altitude flying and is the LPL observer. The first observations of the sun and moon at 1 mm look very promising. The sky is nearly at 0°K above 30,000 ft on good (dry) days if measured at 1 mm.

4. Facilities

The 61-inch NASA telescope was completed during the report period and put into full operation October 8, 1965. The staff participated heavily in the final phases of assembly and testing and several improvements needed to be made during this interval. A detailed account is found in the NASA report on the telescope itself (period 1 April-31 December 1965). I am satisfied that we have succeeded in getting an exceedingly good instrument. The scientific results obtained with it to date prove the excellence of the optics and the stability of the mounting. Reference has been made to the tangent arm for fine motion in declination that still needs to be installed before we can start with infrared scanning program of moon and planets. Also, the telescope should be equipped with a plane-parallel optical plate 45 inches diameter, mounted in a third cage, for elimination of all seeing disturbances within the telescope tube. This project will require another year for its completion. The blank for the optical plate (expense approx. \$12,000) is due early April 1966.* Still to be constructed also is a high-resolution spectrograph. Presently available are a medium-resolution spectrograph, two low-resolution spectrographs, an IR spectrometer, various photometers and a polarimeter for visual and IR radiations, two 5 x 7 inch cameras, two 7-inch roll-film cameras (not yet fully adapted), an 8 x 10 inch plate holder for satellite photography, and a filar micrometer. The dome has less thermal inertia than any other large dome with which I am familiar and has caused a minimum of thermal disturbance during the night observations. It is equipped with four large exhaust fans, each provided with two speeds and an off position, placed in the four quadrants at the observers' level.

In addition, the Catalina observatory has a 21-inch telescope with 20-foot dome, a 28-inch telescope with sliding roof, both described in Sky and Telescope, Vol. 27, Nos. 1 and 2, January and February 1964; a 60-inch IR telescope and a second such telescope under design, with completion schedule for late 1966 (Air Force contract), and a 12-inch photometric telescope, Air Force owned, that may be removed later. A very important addition has been planned to the Catalina Observatory, namely, a 16-inch aperture, 48-inch focus, all-reflecting 2-mirror system, with 8-degree field, designed by our chief optician, Mr. Robert Waland. We hope to be able to proceed with the construction of this novel instrument.

*Received April 8, 1966.

during the second half of 1966 (completion time estimated 9-12 months). This instrument will be very powerful for the study of comets and will be used by Dr. Elizabeth Roemer, who joins the LPL staff 1 June 1966. A 16-inch telescope has been erected on Tumamoc Hill, 6 miles from the Campus, at 3200 ft elevation, but some further improvements are still required before it can be regarded as fully operational. An excellent road to this site was constructed by the University late 1965 so that this observatory will be very convenient for future programs involving comets, asteroids, and other solar-system phenomena. We hope in time to add a Cassegrain telescope, especially for polarization studies to supplement the 16-inch.

5. Site Testing

Mr. Alike Herring of the LPL staff participated on the site-testing program on Mauna Kea and Haleakala through the University of Hawaii.

6. Publications

Of the following LPL publications (published, in press or nearly ready to go to press) some are on subjects other than planets and infrared observations (and have been or are being published on non-NASA funds).

No. of LPL Communications

- 51 "Micrometric Measures of Double Stars"
G. Van Biesbroeck (56 pages)
- 52 "Atmospheric Extinction Corrections in the Infrared"
H. L. Johnson
- 53 "The Absolute Calibration of the Arizona Photometry"
H. L. Johnson
- 54 "Interstellar Extinction in the Galaxy"
H. L. Johnson
- 55 "Infrared Observations of the Neugebauer-Martz-Leighton
Infrared Star in Cygnus"
H. L. Johnson, F. J. Low, and D. Steinmetz
- 56 "Observations of Infrared Stars"
Mendoza V., and W. Z. Wisniewski
- 57 "Modular Optical Test Instrument for 1700-11,000 A"
S. F. Pellicori, E. H. Roland, and T. M. Teska
- 58 "Interpretation of Ranger VII Records"
Gerard P. Kuiper (text reproduced by offset from JPL
Technical Report No. 32-700, a number of critical figures
and plates reworked and improved through new earth-based
photography)
- 59 "Further Observations on the Ranger VII Records"
Ewen A. Whitaker (same treatment as No. 58)

No. of LPL Communication

- 60 "The Reduction of Measures for Position on a Single
Lunar Photograph"
D. W. G. Arthur
- 61 "Selenodetic Measures on Yerkes Lunar Photograph No. 1170"
D. W. G. Arthur
- 62 "The Computation of Selenodetic Coordinates Using the Librations"
D. W. G. Arthur
- 63 "Composition of the Surface Layer of Mars"
A. B. Binder and D. P. Cruikshank
- 64 "Martian Cratering"
W. K. Hartmann
- 65 "Preliminary Drawings of Lunar Limb Areas, VI"
A. K. Herring
- 66 "Observations of Comet Ikeya-Seki (1965f) on Mauna Kea"
A. K. Herring
- 67 "Photographs of Comet Ikeya-Seki"
S. M. Larson and D. G. Milon
- 68 "The 61-inch NASA Telescope of the Catalina Observatory"
G. P. Kuiper
- 69 "Site Survey of Hawaii"
G. P. Kuiper and A. K. Herring
- 70 "The System of Lunar Craters, Quadrant IV"
D. W. G. Arthur, R. H. Pellicori, and C. A. Wood
- 71 "Eight Color Photometry of Bright Stars"
H. L. Johnson (140 pages)

Other publications by LPL staff:

Arthur, D. W. G., "Dispersion in Selenodetic Positions as a Function of Position on the Disk," ICARUS, 1966.

Binder, A. B., "An Analysis of the Preliminary Mariner IV Photographs" Science (in Press).

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Burley, J., and Middlehurst, B. M., 1966, "Transient Lunar Events: Possible Causes," Proc. Nat. Acad. Sci. (in press).

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Herring, A. K., 1965, Observing the Moon-Piton, Sky and Telescope, 30, 251.

Johnson, H. L., Mendoza, V., and Wisniewski, W. Z., 1965, Observations of "Infrared Stars," Ap. J., 142, 1249.

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Kuiper, G. P., 1966, "The Moon and the Planet Mars," in Advances in Earth Science, P. M. Hurley, Ed., (M.I.T. Press).

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Middlehurst, B. M., and Burley, J., 1966, "Catalog of Lunar Events 1587 to 1966 (in press).

Whitaker, E. A., 1965, "Ranger Exploration of the Moon," in Bioastronautics and the Exploration of Space, Bedwell and Stronghold, eds.

_____, "The Ranger Block III Photographic Records," in Rangers VIII and IX Experimenters' Analyses and Interpretations (in press).

Dr. Kuiper and Miss Middlehurst are general editors of the 9-volume series "Stars and Stellar Systems" of which two appeared during the report period: Vol. V, Galactic Structure, edited by A. Blaauw and M. Schmidt; Vol. VIII, Stellar Structure, edited by L. H. Aller and D. B. McLaughlin.